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Parity Effects on Milk Somatic Cell Count in *Bos indicus*: Implications for Sustainable and Productive Dairy Systems

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Studies have revealed that primiparous females with high somatic cell counts (SCC) may be predisposed to a shorter productive life. To this end, the effect of calving on milk composition and somatic cell count was assessed. To this end, 150 cows (75 primiparous and 75 multiparous) managed under grazing conditions (Megathyrsus maximus) were evaluated over a period of 21 days. A 50 mL pool was collected aseptically from the four quarters of each cow. The results showed higher milk production in the multiparous group (P = 0.003). However, the primiparous group of cows was characterised by higher protein content (P = 0.01) with a tendency towards lower SCC (P = 0.07). In addition to this, the fat and total solids contents, as well as protein and non-fat solids, were found to be positively correlated (r = 0.79 to 0.92). Despite this, our study did not show a correlation when we analysed production and SCC, which would indicate that volume alone cannot be a reliable indicator of udder health. In conclusion, parity is a very influential factor in both production volume, milk composition and SCC. Consequently, implementing feeding and management strategies are alternatives for reducing the risk of subclinical mastitis, promoting more sustainable milk production. This information would also serve to strengthen mastitis control programmes, optimising the dairy systems of small producers in tropical regions.

Keywords: Milk composition; Tropical livestock; Small livestock systems; Pastoral systems; Udder health.

INTRODUCTION

According to demographic projections, by 2067 the world population could reach 10.4 billion people, increasing pressure to obtain food. Therefore, there is a need to adopt more intensive livestock systems with a focus on sustainability (Britt et al., 2018). Under current tropical conditions, despite technical and scientific advances in genetics and nutrition, when compared to temperate regions, production yields are still low in both quantity and quality, with alarming repercussions on udder health. This presents us with an increasing challenge to obtain bovine biotypes that are better adapted to constant climate change in order to capture international markets (Britt et al., 2018; Guaman-Rivera et al., 2023). In the global dairy industry, mastitis is one of the main indicators of quality, which is monitored through somatic cell counts. From a clinical point of view, mastitis manifests itself in subclinical or unapparent forms, or in chronic or persistent forms. But regardless of how it presents itself, it reduces production, which affects farmers through penalties in payment (Damm et al., 2017; Kirkeby et al., 2020). Therefore, a biomarker for determining the immune status of the mammary gland is the somatic cell count (SCC). Indeed, extensive evidence from experimental studies has reported that high somatic cell counts are observed in inflamed udders with changes in the chemical components of milk (Juárez et al., 2010). The onset of mastitis is often influenced by several factors, particularly the individual susceptibility of the animal, which is generally associated with high-yield breeds. At the same time, antimicrobial

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resistance due to excessive use of antibiotics is a serious concern, as it has reduced their effectiveness against a wide range of microorganisms. In addition, it has been observed that the number of births significantly affects SCC counts. In fact, primiparous cows, given that they are beginning their productive life, show low SCC counts, unlike multiparous cows, which, due to higher volumes and greater challenges, tend to exceed permitted thresholds. These differences are therefore related to metabolic and physiological aspects according to the condition of the animal (Bytyqi et al., 2010). Keeping an eye on SCC is vital (Raynal-Ljutovac et al., 2007).

In the case of cattle of Indian origin, a different pattern has been observed with regard to SCC, since mastitis in early lactation could affect the productive life of the mother. Consequently, multiparous cows in this case show low SCC counts, which can be explained in part by the immunological challenges that have contributed to the development of an immune memory system in response to exposure to pathogens, which is contrary to primiparous cows. This phenomenon suggests that, at the immune level, animals in tropical conditions are genetically reprogrammed according to the number of lactations (Tyler et al., 1989; Persson Waller et al., 2020). From a more technical and scientific point of view, most experimental work has been carried out on Bos taurus cattle, which leaves a gap in knowledge regarding Indica-type animals. It is necessary to study in greater depth the physiological and/or genetic changes that would affect these populations (Shangraw et al., 2019, 2020; Shangraw & McFadden, 2022). In Ecuador's Amazon region, specifically in the province of Orellana, livestock farming plays an important role in the economy of local families. Data from a study show that of a total of 5,236 agricultural production units (APUs), more than 90% are small-scale or, in other words, subsistence farms (Paredes-Peralta et al., 2024). In this case, considering the types of producers identified, major challenges (access to technology and natural resource management) should be taken into account in order to achieve the long-awaited shift towards more efficient systems from a production standpoint (Blacio et al., 2025; Fuentes-Quisaguano et al., 2022; Guamán-Rivera et al., 2024). Despite the importance of the livestock sector in the Ecuadorian Amazon region and in Orellana, no studies have been conducted to determine the health status of udders, making it difficult to develop joint strategies to disseminate best management practices to producers.

Therefore, in order to be more efficient and capable of better dairy cattle management, we must understand the relationship between the number of calvings and SCC counts. In another context, and considering systems in which people market the production of a single cow, it is necessary to encourage stricter daily monitoring to prevent the onset of mastitis infections that put both the cow's health and the family's finances at risk (Zigo et al., 2021). Taking into account the number of calvings a cow has had when assessing SCC is an important factor when establishing strategies for caring for the health of the mammary gland (Harmon, 1994). By understanding how age at calving directly influences SCC and milk quality, farmers could adopt sustainable practices that not only increase milk production but also maintain high product quality standards. Consequently, this pioneering work fills an important gap by exploring SCC trends as a bioindicator of udder health in Bos indicus cows in the province of Orellana. In this way, these results aim to identify evidence-based strategies to prevent and control mastitis, optimizing the production processes of our animals and significantly improving family income.

MATERIALS AND METHODS

***Animal Welfare and Ethical Approval*:** The activities carried out during the experimental process were performed in accordance with the guidelines of the Animal and Human Ethics Committee, according to Munhall (1988).

***Production System and Environmental Conditions*:** The research was conducted in the La Joya de los Sachas canton, located in the province of Orellana, an area characterized by a humid tropical climate with highly variable environmental conditions. According to data from the Ministry of Agriculture and Livestock, dairy production is more prevalent in this canton compared to other cantons in the province, such as Francisco de Orellana, Loreto, and Aguarico (INAMHI, 2021). The study area is located at an altitude of 275 metres above sea level, with an average annual temperature of 29.7 °C and annual rainfall of 2942 mm/year.

A total of 150 Gyr cows (75 primiparous cows (PM) and 75 multiparous cows (MP) participated in this study, all of them in the first stage of lactation (134 ± 3) with an average milk production of 9.88 kg per day. Their diet consisted mainly of daily grazing on *Megathyrsus maximus* (containing 12% crude protein), supplemented with unrestricted access to white mulberry *(Morus alba*). Milking was performed manually every morning at 7:00 a.m. Inclusion in the study required cows to have an average somatic cell count (SCC) below 220,000 cells/mL to ensure a healthy udder condition at baseline.

***Milk Samples*:** Over the course of 21 days, the study applied a randomized complete block design to assign cows by parity group (primiparous and multiparous). Aseptic samples of 50 ml of milk were collected in sterile bottles and stored at 4 °C with Bronopol (Broad Spectrum Micro-tabs II, D&F Control Systems Inc., San Ramon, California). For analysis, the samples were brought to room temperature in the laboratory and then analysed by infrared spectrophotometry to determine protein, fat, lactose and non-fat solids. SCC was assessed using a calibrated Fossomatic 500 (Foss-Electric, Hillerød, Denmark).

***Statistical Analysis*:** Data analysis was performed using the PROC MIXED procedure in SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA). Prior to the analysis, somatic cell counts were performed. The values (SCC) were transformed using log10, adhering to the assumptions of normality and homogeneity of variance. The statistical model included parity (primiparous vs. multiparous) as a fixed factor, while individual cows and residual error terms were specified as random effects to account for the hierarchical structure of the data and their respective means. Least squares means (LSM) were calculated for the fixed values.
Effects and pairwise comparisons were performed using the PDIFF option with Tukey's test to control for multiple testing. Additionally, correlations between milk composition traits and logarithmically transformed SCC values were assessed using the PROC CORR procedure. Statistical significance was then established at $p < 0.05$, and trends were considered when $p < 0.10$.

RESULTS

Table 1 shows the results for milk production, milk composition, and somatic cell count between primiparous and multiparous cows. At the beginning of the study, there were no statistically significant differences in average daily milk production between the two groups ($p > 0.05$), with a mean of 134 days for the primiparous group and 136 days for the multiparous group. However, parity showed a significant impact on milk production ($p = 0.003$). Multiparous cows produced approximately 15% more milk per day than primiparous cows, with values of 10.83 kg/day compared to 9.18 ± 0.38 kg/day, respectively.

Table 1. Comparison of somatic cell count and milk production parameters between primiparous cow's vs. multiparous cows.

Parameter	Primi-parous	Multi-parous	SEM	P-value
Milk Production				
Milk yield (kg/d)	9.18[b]	10.83[a]	0.38	0.003
Fat-corrected milk (L/d)[1]	6.80[b]	8.26[a]	0.34	0.002
Milk Composition (%)				
Total solids	11.10	11.17	0.17	0.76
Solids-not-fat	8.68	8.66	0.66	0.79
Fat	2.41	2.51	0.16	0.68
Protein	3.24	3.23	0.50	0.85
Lactose	4.71	4.69	0.02	0.60
Nutrient Yield (g/d)				
Fat yield	208[b]	261[a]	16	0.02
Protein yield	299[a]	253[b]	14	0.01
Somatic Cell Count				
SCC (log_{10} cells/mL)	1.89	2.13	0.05	0.07

[1]Fat corrected milk at 4%; FCM = kg of milk yield × [0.4+ 0.15 × (fat %)]

Regarding the percentage of fat in the milk, this differed significantly between the groups with a mean value of 2.46 ± 0.16%, $p = 0.68$, while the fat-corrected milk in multiparous cows was higher with 8.26% in contrast to the group of primiparous cows with 6.80 ± 0.34, as shown in Table 1. As indicated in Table 1, parity had a clear effect on milk production and fat-corrected milk (FCM), but the main compositional parameters total solids, solids-not-fat, fat, protein, and lactose did not differ significantly between primiparous cows and multiparous cows. Across all animals, mean values were 11.14 ± 0.17% for total solids, 8.67 ± 0.66% for solids-not-fat, 3.24 ± 0.50% for protein, and 4.70 ± 0.02% for lactose. When evaluating absolute daily yield, notable differences related to parity were observed. Multiparous cows produced significantly more fat per day at 261 g/d compared to primiparous cows at 208 g/d. Conversely, protein yield was higher in primiparous cows at 299 g/d, while multiparous cows yielded 253 ± 14 g/d. $p = 0.01$).

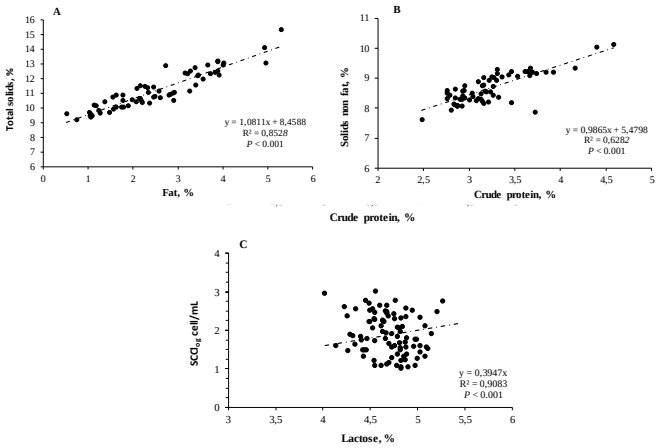

Figure 1. Linear regression analysis illustrating the relationships between total solids and fats (A), non-fat solids and crude protein (B), and somatic cell count and lactose (C).

Table 2 provides a detailed description of the correlations between milk production, composition parameters, and somatic cell count. It was obtained association was detected between milk yield and SCC, with correlation coefficients ranging from -0.04 to 0.67 (P = 0.50 to 0.64). This indicates that within this Gyr cow population, milk volume was not a reliable indicator of udder health. Conversely, strong and highly significant positive correlations were observed between key milk components in both the primiparous and multiparous cow groups. Total solids were strongly correlated with fat content (r = 0.92 to 0.94), indicating the major contribution of fat to total solids. Similarly, non-fat solids showed strong correlations with crude protein (r = 0.79 to 0.90), highlighting the close biochemical link between these

non-fat components.

Table 2. Correlation coefficient(r) and p-value, between performance parameters and milk composition in primiparous and multiparous Bos indicus cows.

Variable	PM (r, P)	MP (r, P)
Milk yield - Fat	-0.25 (0.013)	-0.22 (0.069)
Milk yield - Crude Protein (CP)	0.14 (0.160)	0.22 (0.060)
Milk yield - Total Solids (TS)	-0.15 (0.140)	-0.08 (0.520)
Milk yield - Solids Non-Fat (SNF)	0.25 (0.013)	0.28 (0.010)
Fat - CP	0.00 (0.990)	0.27 (0.020)
Fat - TS	0.94 (0.001)	0.92 (0.001)
CP - TS	0.30 (0.003)	0.54 (0.001)
CP - SNF	0.90 (0.001)	0.79 (0.001)
TS - SNF	0.36 (0.001)	0.54 (0.001)

r = Pearson correlation coefficient; Significant correlations ($P < 0.05$)

DISCUSSION

The lactation period in cows is crucial, creating a significant impact on both milk production and the animal's overall health. To assess udder health and, consequently, milk quality, we use the somatic cell count method, which measures how the mammary gland reacts to infections or inflammation. During the early lactation phase, we observed differences in somatic cell count between primiparous and multiparous cows. However, in tropical environments, evaluating milk production becomes even more complex because milk let-down depends largely on calf stimulation (Coulibaly and Nialibouly, 1998). The method used by (DIM) resulted in higher milk yields (22 ± 1.7 kg/d) and fat content (2.81 ± 0.1%) compared to the findings reported by Martínez-Velázquez et al. (2010). In addition, studies on Zebu dairy cattle indicated lower milk yields (1.3 kg/d) but higher fat percentages (4.88%) than the results of the current study (10 kg/d and 2.46%, respectively) (Millogo et al., 2009).

It is suspected that the lower fat content observed could be related to poor forage quality, likely due to inadequate grazing management, which coincides with findings in the province of Orellana (Guaman-Rivera et al., 2023; Guerrero-Pincay et al., 2023, 2025). Implementing nutritional strategies, especially those that improve mineral and vitamin intake, can enhance immune function and potentially influence somatic cell count levels (Mondini et al., 2024). To effectively control somatic cell counts, it is essential to closely and consistently monitor the udder health of our animals. This involves continuous monitoring to rule out mastitis and regular microbiological analysis of milk (Hisira et al., 2023). It is worth noting that the fat content in milk reflects the nutritional contribution provided during the drying period, which became deficient under the conditions of our study (Bonfoh et al., 2005; Farahani et al., 2017).

It is important to note that the amount of milk a calf ingests can significantly impact daily variations in milk production. Furthermore, we know that as the udder empties, milk fat concentrations tend to increase. Both the calf's presence and udder emptying influence milk fat content (Millogo et al., 2009). A key finding in this study is that no significant differences in fat content were observed between first-calf heifers and those that had previously calved, despite previous research indicating that fat concentrations increased when milk production decreased (Farahani et al., 2017). These findings highlight the inherent complexity of accurately estimating milk production in lactating cows, largely due to their physiological dependence on calf stimulation for milk let-down (Coulibaly and Nialibouly, 1998). In order to counteract this dependency factor, our study was carried out at 134 days of production when the influence of the calf on lactation is not of great importance.

Lactose content showed no significant differences between primiparous and multiparous cows, yielding an average of 4.70 ± 0.02%, values that agree with those proposed by Bonfoh et al. (2005; 4.84%), Martínez-Velázquez et al. (2010; 4.71%), and Sidibe-Anago et al. (2006; 4.6%). However, the correlations between somatic cell count and lactose were relatively weak in both groups (r = 0.22 to 0.25), but statistically significant (P = 0.03 to 0.04). According to Portnoy and Barbano (2021), lactose, as the main carbohydrate in milk, is normally around 4.6% and plays a crucial role in milk secretion by maintaining osmotic balance within mammary epithelial cells. Reductions in lactose concentration are often linked to lower milk production and changes in milk composition, primarily in cows with intramammary infections (Kvidera et al., 2017; Merin et al., 2004; Gross et al., 2020). Therefore, ensuring sufficient lactose levels is crucial for producing high-quality milk, which plays a key role in the safety and quality of dairy products (Albenzio et al., 2019). Mastitis remains a significant problem in dairy production worldwide, causing substantial economic losses, antibiotic dependence, and adverse effects on animal welfare. Continuous monitoring of mastitis allows for understanding how the mammary gland responds to potential inflammation (Wall et al., 2018).

In the case of Bos taurus breeds, a common reference point is established at 200,000 cells/ml to differentiate between healthy and infected mammary quarters (Bradley and Green, 2005). However, for Bos indicus breeds, reliable reference values are difficult to obtain due to the varied data presented, which complicates the establishment of clear diagnostic standards. Several factors can interfere with SCC levels, such as parity, stage of lactation, and management environment. Research indicates that primiparous cows tend to have stronger immune responses in their mammary glands during lactation compared to animals with multiple parities.

Alhussien and Dang (2018) and Moradi et al. (2021) point out that extrinsic factors such as seasonal changes can significantly affect SCC, as SCC levels tend to increase due to increased bacterial activity. We know that the implications of somatic cell count (SCC) not only influence udder health but also affect overall milk production and the financial success of dairy farms. While it is true that multiparous cows tend to have higher milk production, their SCC levels do not differ significantly from those of primiparous cows, suggesting that both groups maintain similar udder health despite differences in production volume (Hisira et al., 2023). In Ecuador, the legal standard stipulated that an uninfected mammary quarter was one with a somatic cell count (SCC) below 500,000 cells/ml. However, it has been reported that approximately 9% of cows presented mean SCC values above 640,000 cells/ml (Bonfoh et al., 2005), and similar observations have shown levels as high as 800,000 cells/ml (Juozaitiene et al., 2006). In the current study among primiparous cows, 57% and 43% presented SCC values below 39,000 and 180,000 cells/ml, respectively. Conversely, in the case of multiparous cows, 65% presented SCC levels above 81,000 cells/ml and 35% exceeded 979,000 cells/ml, results that indicate that multiparous cows have a greater risk of developing subclinical mastitis (Juozaitiene et al., 2006).

Orman et al. (2011) reported comparable patterns in dairy sheep, where somatic cell count (SCC) showed a negative correlation with both milk production and number of calvings. This finding supports our observations that primiparous cows exhibited lower SCC compared to multiparous cows. Factors such as high temperatures and humidity in our tropical environment can subject animals to significant stress, causing heat stress that triggers a series of physical, biochemical, and immune changes. However, as previously mentioned, obtaining reliable reference values for SCC in Bos indicus cattle is complex due to significant variation, making it difficult to establish clear diagnostic standards. Research indicates that primiparous cows, unlike multiparous cows, tend to exhibit stronger immune responses in their mammary glands during lactation (Rakib et al., 2020). The innate immune system is crucial during lactation as it helps prevent intramammary infections (Hadfield et al., 2018). It is known that when the immune system is impaired, the risk of mastitis increases, which is often reflected in higher somatic cell counts (SCC) (Böker et al., 2023). Similarly, when infections occur, the body releases proinflammatory cytokines, which can further impair the immune response and the health of the mammary glands during lactation (Abdo-Rizk et al., 2021; Albenzio et al., 2019; García et al., 2021; McCusker and Kelley, 2013). In multiparous cows, their immune responses may change due to adaptations from previous lactations, which can alter SCC patterns compared to primiparous cows (Böker et al., 2023; Horky et al., 2019; Medina-Córdova et al., 2018; Netea et al., 2015). While mastitis significantly influences many milk characteristics, our research did not reveal relevant links between somatic cell count (SCC) and milk composition traits. However, we recognize that various factors such as season, stage of lactation, genetic background, production systems, and udder or teat structure can reflect this variability in SCC (Collier et al., 2006). Environmental factors can become fundamental and directly influence SCC determination due to the complications it can cause for animals (Mondini et al., 2024). Furthermore, heat stress can compromise the immune system, leading to an increased somatic cell count as part of the body's defense strategy (Böker et al., 2023; Mondini et al., 2024; Sanchez et al., 2013).

***Conclusions*:** This study provides new insights into the variation associated with parity in somatic cell count and milk composition in Bos indicus cows under tropical conditions. Multiparous cows demonstrated higher milk and fat-corrected milk production, while primiparous animals exhibited higher protein production and generally lower somatic cell count (SCC) levels. Although statistically significant differences in SCC were not found, observed patterns indicate that multiparous cows may face a higher risk of subclinical mastitis. Since no relevant correlations were found between SCC and milk production or composition, it is suggested that SCC alone is not a reliable measure of productivity. These findings suggest the need for focused udder health monitoring and efficient nutritional management, especially for multiparous cows, to counteract the various challenges that may arise under our tropical conditions, thereby improving the productive processes of our animals and enhancing the final quality of the milk.

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***SDGs addressed*:** Zero Hunger, Decent Work and Economic Growth, Responsible Consumption and Production, and Climate Action.

***Policy referred*:** Regional Agricultural Development Policy.

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